Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VII (NEW) EXAMINATION – WINTER 2022

Subject Code:3170501 Date:03-01-2023

Subject Name:Chemical Reactions Engineering II

Time:10:30 AM TO 01:00 PM Total Marks:70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

			MARKS
Q.1	**(a)**	Discuss in brief the fluid – solid reactions in which the solid does not appreciably change in size during reaction with suitable example.	**03**
	(b)	A batch of solids of uniform size is treated by gas in a uniform environment. Solid is converted to give a non-flaking product according to the shrinking-core model. Conversion is about 7/8 for a reaction time of 1 h; conversion is complete in two hours. What mechanism is rate controlling?	**04**
	(c)	Gas containing A contacts and reacts with a semi-infinite slab of the solid B as $A_{(g)} + B_{(s)} \rightarrow R_{(g)} + S_{(s)}$. As reaction progresses, a sharp reaction plane advances slowly into the solid leaving behind it a layer of product through which gaseous A and R must diffuse. Overall three resistances act in series that of the gas film, the ash layer, and the reaction. Noting that the rate of thickening of the ash layer is proportional to the rate of reaction at that instant or $\frac{dL}{dt} = M(-r_A)$ and the product layer diffusion rate $= D_e \frac{\Delta C}{L}$. If diffusion through ash layer controls, show that $t_{AshLayer} = \frac{L^2}{2\,M\,D_e\,C_{Ag}}$	**07**
Q.2	**(a)**	Explain in brief about monolithic catalyst and molecular sieves.	**03**
	(b)	The rate law hydrogenation (H) of ethylene (E) to form ethane (A) over a cobalt – molybdenum catalyst is: $$-r_E = \frac{k\,P_E\,P_H}{1 + k_E\,P_E}$$ Suggest a mechanism and rate limiting step consistent with the rate law.	**04**
	(c)	An instantaneous reaction takes place between gas A and spherical solid B giving rise to a hot solid product S and gaseous product R. The rate of consumption of A is same as that of formation of R. Assume that reaction is reversible and gas film resistance is negligible. Show that flux of gas A through the exterior surface of solid is $$Q_{AS} = \frac{D_e r_c (C_{Ag} - C_{Ae})}{R(R - r_c)}$$	**07**

where D_e is diffusivity of gas A through solid, C_{Ag} & C_{Ae} are bulk and equilibrium concentration of gas A respectively, R & r_c are radius of solid particle and unreacted core respectively. How does above equation is simplified when reaction goes to completion?

OR

(c) Spherical particles of zinc blende of size R = 1 mm are roasted in an 8% oxygen stream at 900°C and 1 atm. The stoichiometry of the reaction is: $2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$. Assuming that reaction proceeds by the shrinking – core model. Calculate the time needed for complete conversion of a particle and the relative resistance of ash layer diffusion during this operation. ***Data:*** Density of solid, $\rho_B = 4.13$ gm/cm^3, reaction rate constant, k" = 2 cm/sec, for gases in the ZnO layer, $D_e = 0.08$ cm^2/sec, molecular weight of Zn = 65.38 g/mol and S = 32 g/mol. Note that film resistance can safely be neglected as long as a growing ash layer is present. **07**

Q.3 **(a)** Discuss the spectrum of kinetic regimes for porous catalyst surrounded by a reactant. **03**

(b) Discuss steps involved in catalytic reaction with neat sketch. **04**

(c) Write a detailed note on: catalyst promoters, inhibitors and poisons. **07**

OR

Q.3 **(a)** Distinguish between van der Waal's adsorption and activated adsorption with suitable example. **03**

(b) The desorption of gaseous species C from active site "S" of catalyst is given as $C.S \rightleftharpoons C + S$. Derive the rate law for desorption phenomena. **04**

(c) Discuss about the surface area determination of catalysts by mercury penetration method. **07**

Q.4 **(a)** Discuss the steps to determine the volume of reactor for mass transfer and reaction in agitated tank contactor for mixed flow of gas and liquid. **03**

(b) Write a short note on slurry reactor. **04**

(c) Hydrogen sulfide (H_2S) of 0.10 % by volume in a carrier gas at 2 MPa is to be absorbed at 20 ^oC by a solution containing 250 mol/m^3 methanolamine (MEA). H_2S reacts with MEA irreversibly as per the following reaction. If the diffusivity of MEA in solution is 0.64 times that of H_2S, calculate the enhancement factor for the given reaction. **07**

$$H_2S + MEA \rightarrow HS^- + RNH_3^+$$

Data: $K_{Al,}\, a = 0.03$ sec^{-1}, $K_{Ag,}\, a = 6 \times 10^{-4}$ mol/(sec m^3 Pa), Henry's law constant for H_2S in water $H_A = 10$ Pa m^3/mol.

OR

Q.4 **(a)** State the various types of tower and tank contactors for gas – liquid reaction. **03**

(b) Write a short note on trickle bed reactor. **04**

(c) It is proposed to remove CO_2 from air by counter current contact with water at 25 ^oC. (i) Calculate the resistances offered by the gas and liquid film (ii) Suggest the simplest form of rate equation for tower design. **07**

Data: Kg.a = 0.8 mol/hr m^3 Pa, K_l.a = 25 / hr, Henry's constant H = 3000 Pa m^3 / mol.

Q.5	**(a)**	State the mass transfer correlations for fluidized bed catalytic reactor.	**03**
	(b)	Write merits and demerits of fixed bed reactors.	**04**
	(c)	Discuss the experimental methods for finding rate law consistent with experimental data with suitable example.	**07**

OR

Q.5	**(a)**	What is meant by interphase effectiveness factor for isothermal catalytic reaction?	**03**
	(b)	Write algorithm for determining reaction mechanism, rate limiting step and rate law for isomerization of n-pentene to i-pentene over alumina as a catalyst.	**04**
	(c)	Derive design equation for packed bed catalytic reactor.	**07**

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